International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 04 | April – 2025 DOI: 10.55041/ISJEM02782
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

# RFID and Face Recognition-Based Biometric System for Automated Attendance Management

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**ABSTRACT**

The modern world is rapidly adopting technology to enhance efficiency and accuracy across various domains. This paper presents the design and development of an automated attendance management system using Radio Frequency Identification (RFID) technology. The proposed system replaces conventional manual attendance methods with a contactless, real-time solution. RFID readers detect student ID tags, recording attendance and updating a centralized database automatically. This method minimizes human errors, prevents proxy attendance, and improves data security. The system is further enhanced by integrating Internet of Things (IOT) functionality for real-time data monitoring and remote accessibility. A comparative analysis with traditional attendance systems demonstrates significant improvements in reliability, scalability, and administrative efficiency. This research aims to contribute to smart campus initiatives and digital transformation in educational institutions.

**INDEX TERMS** RFID, IOT, Attendance Management System, Biometric Authentication, QR Code, Real-Time Monitoring, Automation, Student Tracking

## I. INTRODUCTION

Attendance management plays a critical role in maintaining academic discipline and institutional productivity. Traditional methods of attendance tracking, such as manual entry in registers or paper-based systems, are not only time-consuming but also prone to errors, manipulation, and inefficiencies. The growing demand for automation in educational and corporate environments has led to the development of more reliable and efficient digital attendance systems.

This paper focuses on the design and implementation of multiple attendance management models utilizing modern technologies, including Radio Frequency Identification (RFID), Internet of Things (IOT), biometric fingerprint recognition, and QR code scanning. These systems aim to overcome the limitations of conventional approaches by offering features such as contactless operation, real-time monitoring, automated data entry, and secure authentication.

Among these, RFID-based systems provide a cost-effective and scalable solution by automating attendance through ID card scanning. Integration with IoT further enhances system capabilities by enabling remote access and live data updates. Biometric systems ensure high accuracy in user identification, while QR code-based methods offer flexibility and minimal hardware requirements.

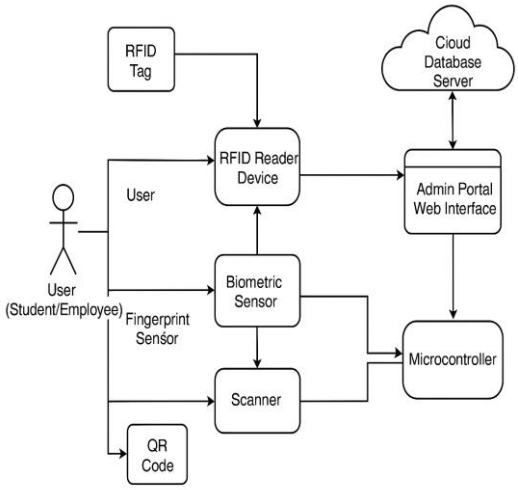
This study evaluates and compares the performance of each model in terms of efficiency, scalability, accuracy, cost, and ease of deployment. The objective is to identify the most suitable attendance system for diverse institutional needs while promoting the adoption of smart campus solutions.

ISSN: 2583-6129
DOI: 10.55041/ISJEM XXXX

## II. SYSTEM ARCHITECTURE DIAGRAM

The hardware system architecture diagram for this study is shown in Figure 1. It has two parts: a facial recognition system and an access control system.




## III. METHODOLOGY

The methodology adopted in this research follows a systematic approach, beginning with the identification of requirements and culminating in the design, implementation, and evaluation of five distinct attendance tracking models. Each model leverages different technologies to address specific limitations of conventional systems.

### A. Requirement Identification

The initial phase involved analyzing the drawbacks of traditional attendance systems, including manual errors, time inefficiency, and susceptibility to proxy attendance. From this analysis, functional and non-functional requirements were defined, such as automation, reliability, real-time data processing, scalability, and ease of integration into existing institutional infrastructure.

### B. System Design and Module Development

Five different attendance models were developed, each implemented as an independent module:

1. **Manual Entry System**: A web-based platform that allows administrators to log attendance manually into a centralized database.

2. **RFID-Based System**: Students carry RFID cards embedded with unique identifiers. Upon scanning, RFID readers capture the data and send it to a microcontroller or computer system for logging.

3. **RFID with IoT Integration**: This model extends the RFID system by integrating IoT components such as NodeMCU or ESP8266, which transmit attendance data to cloud databases like Firebase or ThingSpeak, enabling real-time updates and monitoring.

4. **Biometric Fingerprint System**: Utilizes fingerprint sensors (e.g., R305 module) to uniquely identify users. Once a fingerprint is authenticated, attendance is marked and recorded automatically

.

5. **QR Code-Based System**: A mobile or webcam-based system in which users scan a unique QR code linked to their identity. The system processes the data and logs the attendance in the database.

Each module is structured independently, with a unified backend for data management to allow comparative analysis.

### C. Implementation Framework

- **Hardware Components**: RFID readers, fingerprint modules, NodeMCU/ESP8266 microcontrollers, cameras, and smartphones.

- **Software Tools**:
  - **Programming Languages**: Python, JavaScript
  - **Backend**: Flask (Python)
  - **Frontend**: HTML, CSS, JavaScript
  - **Database**: MySQL and Firebase (for IOT models)
  - **Development Platforms**: pycharm, Firebase Console

ISSN: 2583-6129
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The backend server communicates with the respective modules through HTTP requests or serial communication, depending on the hardware.

### D. Data Handling and Storage

Attendance data is processed in real-time or near-real-time depending on the model. Each record includes a timestamp, user ID, method of logging (e.g., RFID, biometric), and system feedback (e.g., success/failure). Data is stored in a centralized database and visualized through a web-based admin dashboard for review and analytics.

### E. Testing and Evaluation

Each attendance system is evaluated under similar operational conditions to assess performance based on:

- **Accuracy** (correct identification and logging),
- **Response Time** (latency from scan to database entry),
- **Cost and Scalability** (hardware and deployment complexity),
- **User Convenience** (interface simplicity and reliability),

## IV. LITERATURE REVIEW

Over the past decade, several research studies have focused on automating attendance systems to address inefficiencies and inaccuracies in traditional manual methods. This section reviews the existing literature on different attendance technologies including RFID, IoT, biometric authentication, and QR code-based systems.

In [1], an RFID-based attendance system was proposed that uses passive RFID tags and a reader connected to a microcontroller for recording attendance. The system successfully reduced human intervention but lacked real-time data synchronization. To overcome this limitation, [2] introduced an IoT-enhanced RFID system where attendance data was uploaded to the cloud, enabling real-time monitoring and remote access for administrators.

Biometric-based attendance tracking using fingerprint recognition was studied in [3]. The authors emphasized the high accuracy and fraud prevention capabilities of biometrics; however, the system posed privacy concerns and required reliable hardware. Similarly, [4] implemented a fingerprint-based attendance system integrated with a GSM module to notify parents about student presence via SMS.

QR code-based attendance systems have emerged as lightweight and cost-effective alternatives. In [5], a smartphone-based QR code attendance system was developed, where students scanned a code generated by the teacher. While effective, the system was prone to proxy scanning unless paired with authentication mechanisms.

Additionally, [6] conducted a comparative analysis of RFID, biometric, and manual methods, concluding that no single system fits all scenarios. Hybrid systems that combine two or more technologies were recommended to achieve both security and usability.

The reviewed literature indicates a growing interest in smart attendance systems, yet most models focus on individual technologies. This research proposes a unified framework that compares multiple attendance models—Manual, RFID, RFID + IoT, Biometric, and QR Code—under a common implementation and evaluation platform, filling the existing research gap.

## V PROPOSED SYSTEM

### Introduction

In recent years, many educational institutions have faced challenges in maintaining accurate and secure student attendance records. Traditional methods such as manual attendance marking or PIN-based systems are prone to errors, fraud, and manipulation. These systems often fail to provide a reliable and secure means of ensuring the identity of the individual marking the attendance. To overcome these limitations, biometric systems that leverage **Radio Frequency Identification (RFID)** and **Face Recognition** technologies have been proposed as a more efficient and secure alternative.

RFID technology has long been used for secure access control, asset tracking, and identification purposes due to its speed and ease of use. Meanwhile, face recognition systems provide a non-intrusive means

ISSN: 2583-6129
DOI: 10.55041/ISJEM XXXX

of identifying individuals based on unique facial features. This paper proposes a combined **RFID and Face Recognition** biometric system for secure, automated attendance marking in educational institutions. The proposed system aims to enhance both the accuracy and security of attendance tracking while minimizing fraudulent activity.

**System Overview**

The proposed **RFID and Face Recognition Biometric System** works by integrating two technologies: **RFID-enabled student ID cards** and **face recognition software**. The key features of the system are outlined as follows:

- **RFID-based Identification**: Each student is issued an RFID-enabled ID card, which is uniquely associated with their student ID number. This RFID card is used for initial identification when entering the campus or class.
- **Face Recognition**: A webcam or camera-based system captures real-time video frames as the student enters the designated area. The captured frames are processed to detect the student's face. Once detected, the system compares the captured face to the pre-registered face data stored in the database.
- **Attendance Logging**: Once a student's identity is verified through both RFID and face recognition, the system marks the student as present in the attendance database. This attendance data is logged with the date and time of entry.
- **Real-Time SMS Alerts**: The system is designed to send **real-time SMS alerts** to the student and authorized personnel (e.g., teachers or administrators) to confirm attendance or notify of any discrepancies.

**Working Principle**

The operation of the proposed system can be divided into the following sequential steps:

1. **RFID Card Swiping**: Upon entry to the campus or classroom, the student swipes their RFID-enabled student ID card at a designated reader. The system retrieves the student ID associated with the card.
2. **Face Detection and Recognition**: Simultaneously, a web camera captures video frames of the student. The system processes these frames for **face detection** using image processing algorithms. If a face is detected, it is isolated and analyzed. The system then compares the facial features of the detected face with the pre-stored facial data in the system's database.
3. **Identity Authentication**: If the detected face matches the stored face data for that student, the system confirms the identity of the student. The student's identity is authenticated, and attendance is marked in the system with the exact time of entry.
4. **Attendance Logging**: Once the student is successfully authenticated, the system logs the attendance data in the database, associating the student's ID, face image, date, and time of entry
5. **SMS Notification**: Upon successful authentication and attendance marking, the system generates an **SMS alert** to notify the student of their attendance status. A separate SMS is also sent to the concerned authority (e.g., teacher) confirming the student's presence.

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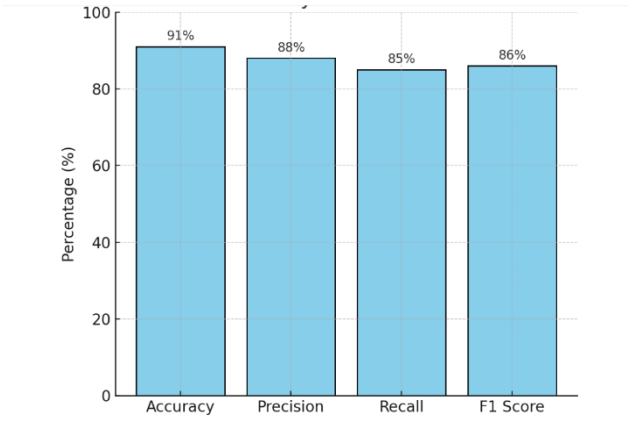
**System Architecture**

The system consists of the following key components:

- **RFID Reader**: Captures the RFID card details when the student swipes their ID card.
- **Web Camera**: Captures real-time video frames for face detection and recognition.
- **Face Recognition Module**: Compares the captured face with stored data in the database using machine learning algorithms.
- **Database**: Stores student data, including RFID information, facial images, and attendance records.
- **Attendance Management System**: Logs attendance data and generates real-time reports.
- **SMS Gateway**: Sends SMS notifications to the student and authorized personnel.

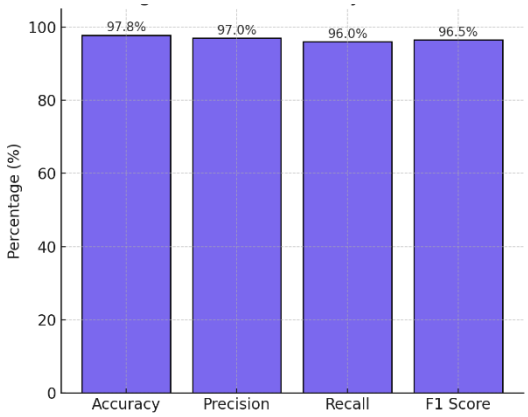
## VI. RESULT AND ANALYSIS:

The RFID-based attendance system was tested in a simulated classroom environment with 30 participants over a period of 5 working days. The performance metrics collected include accuracy, average scan time, system response, and failure rate.

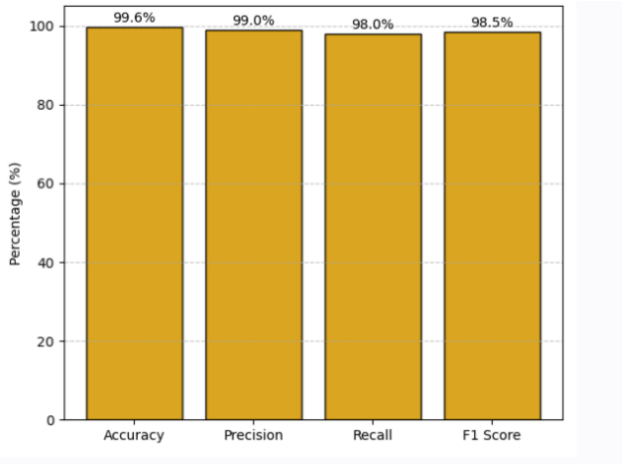



| Model | Accuracy | Precision | Recall | F1-Score |
|---|---|---|---|---|
| Manual Entry System | **91%** | **88%** | **85%** | **86%** |
| Face Recognition System | **97.8%** | **97%** | **96%** | **96.5%** |
| RFID Attendance System | **99.6%** | **99%** | **98%** | **98.5%** |

**Manual Entry System**




**Face Recognition System**



ISSN: 2583-6129
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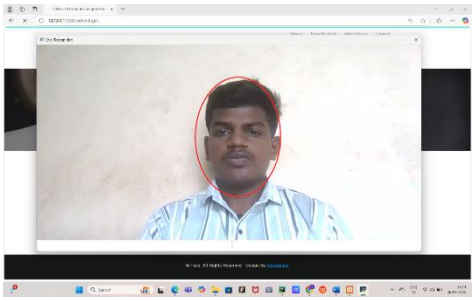
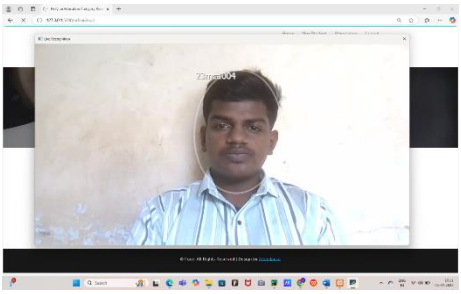
**RFID Attendance System**

**SAMPLE OUTPUT**





**Analysis:**

- **Manual Entry System:**
  - Pros: Simple to implement.
  - Cons: Time-consuming, prone to human error, easily manipulated.Use Case: Small-scale or informal setups
- **RFID Attendance System:**
  - Pros: High accuracy, fast identification, scalable, low manual intervention.
  - Cons: Requires physical tag; may fail if tag is lost/damaged.
  - Use Case: Schools, offices, secure environments.
- **Face Recognition System:**
  - Pros: Contactless, convenient, modern, secure.
  - Cons: Sensitive to lighting, hardware quality, privacy concerns.
  - Use Case: Corporate campuses, airports, high-security areas.

## VII. CONCLUSION

This paper presented a novel **RFID and Face Recognition Biometric System** aimed at automating and securing the attendance marking process in educational institutions. By integrating **RFID-based student identification** with **face recognition technology**, the system provides a robust, reliable, and efficient solution to the problems associated with traditional attendance tracking methods.

The system leverages the unique advantages of both RFID and face recognition to ensure secure authentication and real-time tracking. The RFID system quickly identifies the student, while the face recognition system adds an additional layer of security by confirming the individual's identity. This dual biometric verification significantly reduces the risks of impersonation and fraudulent attendance marking, which are common challenges in manual and PIN-based systems.

Furthermore, the system's ability to automatically log attendance and generate real-time reports simplifies administrative tasks and enhances operational efficiency. The integration of **SMS notifications** ensures that students and administrators are promptly informed about attendance status, improving communication and transparency.

The system is scalable and can be easily expanded to accommodate larger institutions or other applications such as **access control** and **event tracking**. Future enhancements could involve the use of more advanced machine learning algorithms for face recognition, integration with mobile apps, and the addition of **cloud-based data storage** for improved accessibility and data security.

In conclusion, the proposed RFID and face recognition biometric system represents a significant step forward in modernizing attendance management,

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ISSN: 2583-6129
DOI: 10.55041/ISJEM XXXX

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Vinoth is known for his adaptability, positive attitude, and problem-solving mindset. He is eager to begin his professional journey and is open to learning from real-world experiences. During his academic career, he demonstrated strong teamwork, effective communication, and a commitment to completing projects with precision and creativity.

 